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# WATERTOWN ARSENAL LABORATORY

## MEMORANDUM REPORT

NO. WAL 451/13

INSPECTORS' MANUAL

OF

PROCEDURES TO BE USED FOR THE MAGNETIC PARTICLE TESTING OF HELICAL (STEEL) SPRINGS FOR ORDNANCE

BY

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DATE 28 January 1944

WATERTOWN ARSENAL
WATERTOWN, MASS.

# INSPECTORS' MANUAL

# OF

# PROCEDURES TO BE USED FOR THE MAGNETIC PARTICLE TESTING OF HELICAL (STEEL) SPRINGS FOR ORDNANCE

(Wire Diameter = 1/8" or Larger)

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Introduction. The following method and procedures may be used for the examination of helical (steel) springs by magnetic particle testing:-

Method. Direct Method of Magnetization is defined as the method in which an electric current is passed through the piece to be tested by means of contact electrodes which are placed, not in direct contact with the work, but in contact with lead pads interposed between the electrodes and the work.

Procedure A. Use of Particles in Suspension (Commonly Called "Wet Method").

Finely divided ferromagnetic particles suspended in a light oil vehicle are sprayed or flowed onto the piece to be inspected while it is being magnetized or the work may be lowered into a tank containing the agitated suspension while the magnetizing current is being passed through the piece.

Procedure B. Use of Dry Magnetic Particles.

A finely divided dry powder of ferromagnetic material is dusted into relatively still air directly above the work while it is being magnetized and the powder particles allowed to settle on the surface of the work. The presence of even slight drafts or gusts of air may obscure the pattern. The greater the care taken to assure still air above the work, the better.

## Details of Procedures

1. Method of Magnetization. The magnetizing current should be applied in a manner that will prevent overheating of the spring steel either as a whole or locally. A firm, immobile contact is necessary since any movement of the electrodes or contacts while the magnetizing current is on may result in sparking or arcing which may cause local overheating of the spring material at the points of contact. For testing relatively large springs, the electrodes may be clamped against

lead pads in postion, as shown in Fig. 1. A suggested clamp for this purpose is illustrated in Fig. 2. When testing smaller coil springs, lead faced contact plates may be used. If the spring is fairly stiff these plates may be used like vise jaws to hold the spring in firm contact.

If the magnetizing current is passing into the spring wire through a contact area that is too small, the high electrical resistance of steel may cause the immediately adjacent metal to overheat to an extent that may injure the spring. The protecting pads should, therefcre, afford as large a contact area as possible to prevent local overheating from this cause and should be made of some material that has a low melting point such as lead (not less than 1/8" thick for adequate protection.) If sheet lead is not available, copper braid or gauze may be substituted. The low melting lead acts as a safety fuse or heat absorber while the copper braid behaves as a heat dissapator. With either material, the pad should give a fairly large contact area with the work and should contact only the ends of the spring (See Fig. 3). Rust, scale, or other coatings on the spring should be removed at the point of contact and only clean protecting pads should be used in order to reduce the possibilities of sparking. Such precautionary measures must be taken since overheating of air-hardening steels may cause the formation of brittle spots that cannot withstand shock stresses or may even result in the formation of small check cracks, starting points for failure of the spring in service. The presence of small blued or blackened spots on the surface of the work after removal of the electrodes is a sure indication of local overheating.

Heating of the entire spring to a temperature which may result in a change in its mechanical properties is another danger which must be avoided. This overall heating may be controlled by limiting the maount of current passed through the spring or the length of time the current is on. These factors should be such that the work never becomes uncomfortably warm to the touch when the hand is placed in direct contact with ary part of the spring. The current used for magnetization should be limited to approximately 350 to 450 amperes per square inch of cross section magnetized. Direct current is preferable for magnetization, but alternating current of commercial power frequency may be used. The open circuit voltage applied to the work should be no greater than 50 volts. This energy may be obtained from power lines, generators, or rectifiers of proper capacity or rating. Regardless of the source, some means must be provided for turning the current on or off without breaking the circuit at the points of contact with the spring. Breaking the circuit while the current is on will result in severe arcing and certain injury to the spring.

2. Procedure A, (Wet Method). When using Procedure A, the suspension should be prepared as follows:-

The vehicle should be a light oil (kerosene or other similar oil[1]) having approximately the following characteristics:-

| | |
|---|---|
| Flash Point - Closed Cup | 150°F (min.) or legal limit |
| Gravity | 46° A.P.I. (max.) |
| Viscosity (Saybolt Universal at 77°F) | 41 seconds (max.) |
| Color (Saybolt Chromometer) | +25 (min.) |

The finely divided magnetic particles[2] should be mixed with the oil vehicle in proportion of not less than one ounce to the gallon of oil.

A modification of Procedure A[3] provides for the use of magnetic particles which glow when viewed under near-ultra-violet radiation or so-called "black light". The use of this fluorescent suspension increases the sensitivity of the test greatly and is recommended for use wherever possible. The same vehicle may be used in this procedure as that mentioned above, but the concentration of particles in the oil must be lower in order to reduce the background fluorescence. A maximum concentration of fluorescent particles of .50% of the oil by weight is recommended for best results. This concentration must be checked often to prevent excessive background fluorescence.

3. Procedure B. (Dry Method). When using Procedure B, it is advantageous to remove excess dry powder from the spring while the magnetizing current is on. A small hand pump or motor driven pump may be used to supply the air current necessary to blow away this excess powder without removing significant features of the pattern. Only a low velocity current of air should be used. Apparatus is also available from commercial sources for applying the dry powder pneumatically.

4. Interpretation of Results. Magnetization of springs by passing current through them from one end to the other will best detect surface defects that are in a longitudinal direction with respect to the spring wire. Such defects may be considered to be either crack-like or seam-like. Magnetic particle patterns due to crack-like defects will not be absolutely straight but will tend to have components running in different directions. Because of this fact it may be possible sometimes to locate crack-like defects that

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[1] Some commercial products such as Ultrasene, made by the Atlantic Refining Co., and Varsol, manufactured by the Standard Oil Co. have been found to be satisfactory.

[2] Suitable preparations are made by the Magnaflux Corp. under the name of Magnaflux Paste. This paste is available in black and red for color contrast against different backgrounds. Other sources of suitable pastes may exist.

[3] Information in this paragraph has been taken from Report TED No. NAF-25153 on "Fluorescent Magnetic Particle Test", Bureau of Aeronautics, Navy Department. Particles for the fluorescent suspension may also be obtained from Magnaflux Corporation.

are essentially circumferential in the wire by observing the formation of patterns or accumulations of magnetic particles along the longitudinal components of these defects. Seam-like defects tend to be straight or follow the longitudinal axis of the spring wire. A typical pattern indicating a surface seam is shown in Fig. 4. The greater sensitivity of the wet method may result in the formation of patterns due to deep scratches in the surface of the wire. These patterns may be similar to those due to seam-like defects.

Magnetic particle patterns may form that have little or no significance. The occurrence of these patterns is more troublesome in connection with the fluorescent than with the ordinary wet method due to the greater sensitivity of the former. One of the frequent causes of false or meaningless patterns is the manner in which excess fluid is drained from the work. A line of particles sometimes forms along the last locations on the piece to drain. Surface irregularities, such as scale, pits, or impressions in the surface of the material due to manufacturing processes, may also cause the formation of patterns. Such conditions may or may not be cause for rejection, depending upon their severity, but should be carefully considered before acceptance or rejection is made. It is not likely that false patterns will form when the dry powder is used in spring testing. The experienced inspector is not apt to be misled by meaningless patterns, but he should be alert to the possibility of their presence.

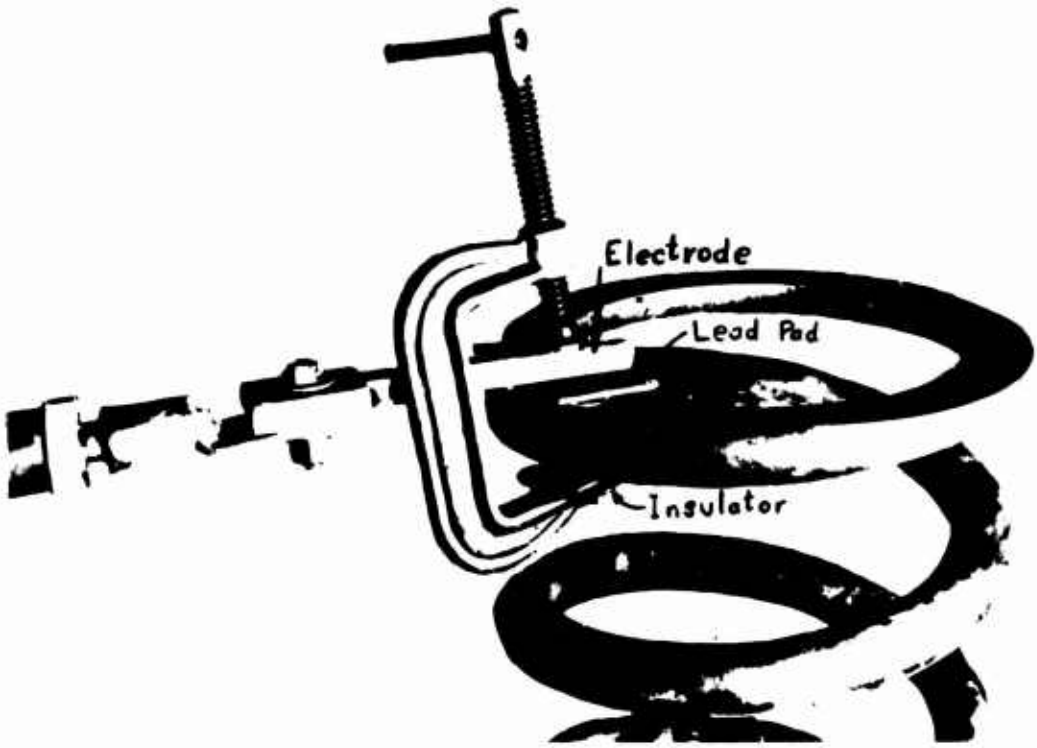


FIGURE 1

DETAILS OF CONTACT AND INSULATION USED WITH DIRECT METHOD OF MAGNETIZING EQUILIBRATOR SPRINGS. A SPECIAL CLAMP MAY BE USED TO ADVANTAGE.

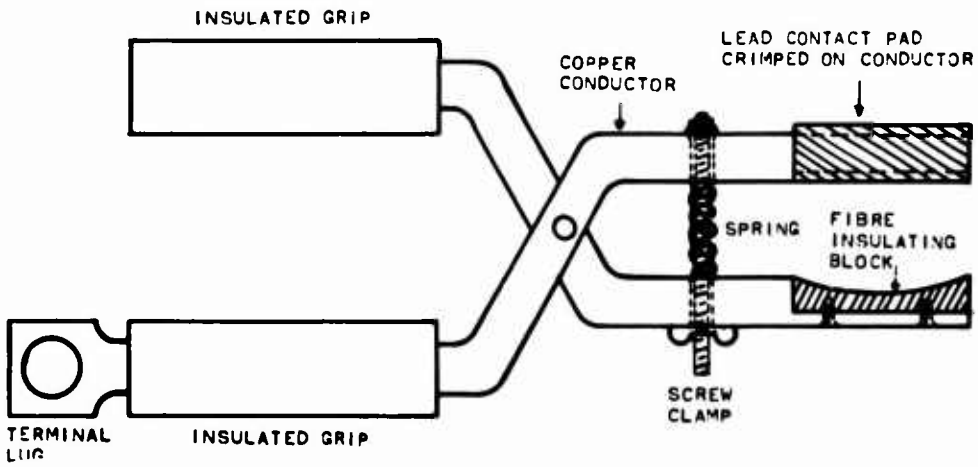


FIGURE 2

SUGGESTED CLAMP FOR MAGNETIC TESTING

FIGURE 3

DIRECT METHOD OF MAGNETIZATION APPLIED TO ENDS OF SPRING ONLY.


FIGURE 4

MAGNETIC POWDER PATTERN INDICATING THE PRESENCE OF A SEAM IN THE SPRING WIRE.